RESEARCH ON QUARANTINE DISINFESTATION OF MANGOS

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Mangos cannot be transported from Hawaii to markets on the U.S. mainland or in other countries that prohibit the entry of fruit fly hosts without quarantine treatment. Mangos in Hawaii presently have no available quarantine treatments to disinfest the fruit of tephritid fruit flies, including Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann); melon fly, *Bactrocera cucurbitae* Coquillett; and oriental fruit fly, *B. dorsalis* Hendel; or the mango (seed) weevil, *Cryptorhynchus mangiferae* (F). Whether mangos can be a host for the so-called Malaysian fruit fly, *B. latifrons* (Hendel), is questionable.

Japan imports mangos from Australia, Philippines, Taiwan, and Thailand after the fruits receive a vapor heat disinfestation treatment that raises the fruit pulp temperature to a specified temperature and holds that temperature for 10–20 minutes before hydrocooling.

The ARS Hilo laboratory recently completed construction of a vapor heat research facility that will be used to provide data to determine the required parameters for an efficacious quarantine treatment using this technology. Meanwhile, we have been developing a high-temperature forced-air treatment that, to date, shows promise in disinfesting Mediterranean and oriental fruit flies from mangos. The treatment consists of heating mangos with forced hot air at 85–95 percent relative humidity. The fruit surfaces remain dry during treatment because the dewpoint of the air is maintained below the fruit surface temperature to preclude condensation onto the fruit. The mango pulp is heated to 47.2°C, measured at the outer seed surface during treatment, followed by hydrocooling until the pulp is 30°C.

The data required to demonstrate a probit 9 quarantine security to USDA–APHIS is a treated population of 100,000 target insects of the most heat-tolerant life stages with no more than three survivors. Mediterranean and oriental fruit flies are the most heat-tolerant species, and the late-aged eggs and first instar larvae are the most heat-tolerant life stages.

Our accumulated data for the forced hot-air treatment are:

370,805 Mediterranean fruit fly eggs treated, with four survivors.

25,318 Mediterranean fruit fly first instar larvae treated, with zero survivors (74,682 more needed to complete data).

443,789 oriental fruit fly eggs treated, with zero survivors.

114,676 oriental fruit fly first instar larvae treated, with zero survivors.

About 30,000 of the less heat-tolerant life stages are needed to show that the forced hot-air treatment provides quarantine security. We hope to complete these data for the forced hot-air treatment this year during mango harvest season.

Vapor-heat treatment is identical to a forced hot-air treatment except that water condenses on the fruit surfaces during all or some part of the treatment process. When the forced hot-air treatment data is complete, we will test a vapor-heat treatment to show corresponding pulp temperature profiles and insect mortality using Mediterranean and oriental fruit fly eggs and larvae. One to two years will be required to complete this work to provide a second quarantine treatment.

Mango weevil remains a major problem. No available treatment technology, other than irradiation, has shown promise as a quarantine treatment, and the temperatures and times required to kill mango weevil with heat also damage the fruit. Microwave treatment, ultrasound detection, and field sanitation were found ineffective. So long as there is no available quarantine treatment against mango weevil, USDA–APHIS may not allow the entry of mangos from Hawaii into the U.S. mainland regardless of applicable fruit fly disinfestation treatments. Japan imports mangos from countries where mango weevil occurs and, although there is a zero tolerance for mango weevil, evidently does not inspect for this insect *at this time*. With applicable quarantine treatments against fruit flies, some countries may accept mangos from Hawaii without disinfestation treatment against mango weevil. The inherent danger is that quarantine regulations may change.

Q: What is the distribution of the mango weevil?

A: The survey that Jim Hansen and I did during the 1986 mango season found mango weevil on every island and in almost every orchard where we looked; the only differences were the percentages of infested mangos in any particular orchard. We did orchard sanitation studies where we removed the fruits and seeds from the ground, but after two years of tests we found more weevils in the treated orchard plots than in the controls. Apparently there were enough non-cultivated mango trees growing wild near the test orchards to provide more mango weevils, and therefore the orchard sanitation did not work. We forced adult weevils to fly in the laboratory by placing them on the ends of dowels with a sticky barrier around the sides that the insect could not pass; the weevils eventually took flight from the dowels and flew around the laboratory for several minutes. This demonstrated that, contrary to reports in the literature, this insect is capable of sustained flight. This may explain in part how the mango weevil becomes distributed, and why our orchard sanitation tests failed to control this insect.

Cathy Cavaletto: I should add that when we did our studies using X rays to detect mango weevil, we compared varieties from one location and observed what seemed to be large differences in infestation among varieties.

A: We also noted that during our survey, but we did not develop sufficient data to analyze for major differences. The problem is that regulatory agencies generally regard a fruit as a host or a non-host, and it is difficult to prove that an individual cultivar is not a host when many other cultivars of that fruit are hosts. A seedless mango would, of course alleviate this problem.

Q: Have you done irradiation research?

A: We are not equipped to do irradiation work at our laboratory. However, one of my counterparts in Australia informed me that dosages required to kill mango weevil caused damage to the fruit. Because of this damage and the question of consumer acceptance, Australia dropped that approach, and now they use vapor-heat treatment against fruit flies. When I asked him what they did about mango weevil in regard to exporting mango to Japan, he told me that although Japan has a zero tolerance for mango weevil, Japan does not inspect for mango weevil because mangos are not grown in Japan. Of course, regulatory agencies can change such policies at any time.

Q: How did the ultrasound technique work?

A: We used ultrasound detection systems to listen to mango weevil and fruit fly larvae. We could actually hear the insects moving about inside the fruit, especially when they were feeding. This approach was dropped because there were too many false positive or false negative readings caused by other factors in the fruit, such as gas movement in ripening fruits, or because the larvae occasionally became quiescent and made no sounds we could detect.

Q: Why wasn't microwave effective?

A: We found that the types of equipment we were using caused uneven heating of the fruit, which tended to cook parts of the fruit. Also, air in the seed cavity expanded when heated, causing the mango to explode. We need to use microwave equipment that will permit differential heating, i.e., heating the insects without heating the fruit. Contacts I have made with microwave researchers in the military-industrial sector indicated to me that such technology was available and that it may be possible to target the insect without heating the fruit. New Zealand's HortResearch group in Auckland is conducting research in microwave technology as a disinfestation treatment for a number of insects, and a colleague in Thailand recently told me that Japan is planning to begin testing a microwave treatment facility in Bangkok for quarantine treatment purposes. This is an exciting area of technology with potential use in quarantine treatments.

Q: Does the mango weevil attack other fruits?

A: No, it is host-specific to the mango. There are two species of the mango weevil. The one we have attacks the seed and is rarely found in the flesh. The other species tends to attack the flesh and is found in India and elsewhere.

Q: Would ultrasound technology, such as is used to break up kidney stones, possibly be effective against the weevils in the seed?

A: We did some work with that, briefly and without success. You'll note that kidney-stone patients are placed in a water bath, because water is the best way of transmitting ultrasounds. The ultrasound heats up the water, and we thought that

was a rather expensive way to get hot-water immersion. It also tends to affect the fruit surface; there is not a lot of penetration.

Q: When does the adult weevil leave the seed?

A: It has been our experience that the adult leaves the seed after the flesh has rotted away and the seed is naked on the ground. The seed then splits with age, or openings occur from deterioration. During our survey, we found it difficult to find adults outside of the seeds. Several of us spent three days collecting only about a dozen adult weevils. They tend to hide in the bark of the trees, and they may hide in the lava rock in mango orchards on the Big Island; we call this cryptic activity "overseasoning" from one mango season to the next, since we do not have a real winter here. They hide very well, for a very long time.

Q: Why is mango weevil quarantined from the U.S. mainland?

A: Regulatory statute prohibits the transport of any live insects from Hawaii to the U.S. mainland, Furthermore, mangos are cultivated in Florida, where mango weevil does not yet occur. Even if mango weevil did occur in Florida, the prohibition against the transport of live insects would still be in effect.

Dr. Michael Williamson: I have worked with Dr. Armstrong on the commercial application of dry heat. I had a request from Taiwan to test a vapor-heat chamber there for mangos to certify it for treating against fruit flies. Taiwan is going to be shipping a small amount of mangos in June into California. Taiwan has had this facility for several years, but it has never been certified, so they have never been able to ship their fruit to the U.S. Apparently they don't have the mango weevil. There is a good possibility that vapor-heat treatment could be commercially certified by APHIS for killing fruit flies in mangos, but that doesn't help you with the weevil. The fruit fly problem can definitely be overcome with Dr. Armstrong's dry heat technology.